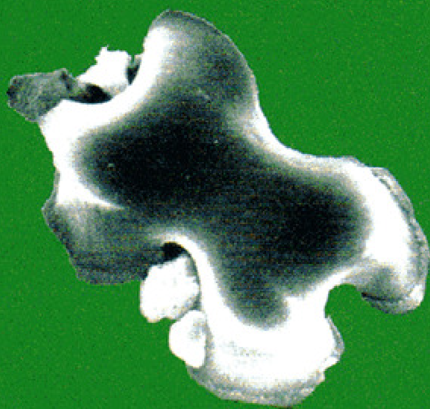
PHYTOLITHS:

Applications in Earth Sciences and Human History



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A METHOD FOR EXAMINATION OF EXOGENUS DEPOSITS ON DENTAL SURFACES

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Abstract

Analysis of dental surface deposits focuses on the form, shape, chemical nature and precise location of the particles. A nitrocellulosic replication technique is presented to "flick away " material coated on ancient teeth and to disclose the basic composition of the deposits. The cases are presented to encourage scientists to inspect the archaeological remains and even to conduct the excavations.

INTRODUCTION

Dental surface deposits from various origins are recorded in archaeology and forensic sciences as an approach to document past ways of life. Use of the morphological and chemical characteristics of these particles is established as a routine procedure for many purposes. Promising evidence about the food consumed, as seen on the teeth of living and extinct hominids, has been described through previous microscopic examination (Ciochon et al. 1990, Lalueza et al. 1996). That the deposits found on tooth surfaces are likely from food consumed during the lifetime of the subject has been inferred from the direct association of abrasive food material and microwear features on the teeth. The nature of digested abrasive substances can be seen from the examination of faeces and coprolites. Bone, tooth and stone granules as well as amorphous silica (opal phytoliths) were recorded (Barker et al. 1959, Puech et al. 1980, Cummings 1993). Identification of exogenous particles was accomplished by the comparison of the phytoliths from the dental calculus of past humans deposits at the surface of teeth from individuals and the phytoliths present in their inner abdominal area (Lalueza, et al. 1996).

Archaeological materials may provide a large variety of substances bound to dental surfaces. Soil staining is present on most ancient teeth from ante- or post-mortem events (Wood-Jones 1908, Puech et al. 1993). The objective of this study is to gather information about exogenous deposits on various archaeological dental surfaces to yield insights into a number of topics, including past environments, taphonomy and life history.

MATERIALS AND METHODS

Explaining behavioral and structural changes in the course of human evolution are among the goals of archaeological studies and tooth surface examination has remained contentious. To avoid damages to the fossil dentition, high-resolution replicas of dental crowns were made over the past few years. The present study concerns the following line of human evolution :

- *Dryopithecus*, a large Miocene hominoid who lived 13-7 million years ago (m.y.a), from the deposit of Can Llobateres (Spain). Spanish dryopithecines are probably from sub-tropical open habitats intermediate between "forested" and "savanna" biotypes (Crusafont-Pairo and Golpe-Posse, 1973).
- *Australopithecus* from Hadar (Ethiopia). It is a good example of early hominins (dated from 4-3 m.y.a). Hadar sites were lakes where silty clay accumulated with laterally fluvial deposit sands. The lakes were destroyed by volcanic ashfalls (Aronson and Taieb 1981).
- *Homo sapiens*, dated 40000 years ago, a neandertal from La Ferrassie (France). Neandertals were the first in the course of human evolution to have buried their dead.
- The modern sample is the recently identified skull of Mozart (1756-1791), deposited at the Mozarteum in Salzbourg (Austria). This skull was exhumed in 1801 at the cemetery in Vienna and many handlings were made since then (Puech et al. 1989).

All teeth were cleaned with alcohol or acetone, and casts were made with nitrocellulosic varnish. The varnish used is a nitrocellulose compound supplemented with a solvent and a plasticiser (Vernis Replic, supplied ready for use by PRESI, Eybens France). A "clear" nail varnish can be suitable for the production of low resolution models. These substances were used because the casts can be initially observed by reflected and transmitted light. They were also chosen because the negative impression provides more details and less artifacts then a two-step replica that produces a positive cast. Examination is seriously compromised by silicon rubber ; such replicas are not convenient for light microscopy and show obvious defects at magnifications of 400x. Similar defects were absent with nitrocellulosic varnish (Unrath and Lindemann 1982-83). The nitrocellulose preparation is poured over the material to be examined. When quite hard (10 – 15 min.) the replicas may be separated and mounted on microscope slide, the edges of which are bound with adhesive tape. These replicas extract, by stripping, the superficial deposits from the teeth. Simple dust, traces of biological tissues and other particles adhere to the replicas. For examination with an electron microscope, a layer of 200 Å gold was applied. Most of the particles are visible under 400x magnification, but higher magnification was used to record the features.

RESULTS

An important prerequisite for the use of nitrocellulosic replicas is that they reliably reproduce the dental surface. Because the stripping process may present some difficulty owing to the tendency of the replica to curl, the faithfulness and the accuracy of the replication were controlled by comparing the replica with the original surface. Serial impressions from the same region have been made because artifacts of various types (pits, bubbles...) have been encountered.

In the *Dryopithecus* sample, slight erosion of surface enamel was observed. The detection at 3000x of surface deposits of alkaline pH such as gypsum, immediately soluble in acid, suggest the impossibility of an acidic degradation after burial and favors an interpretation of acidic foods during life (Figure 1a).

The distribution of particles on the *Australopithecus* sample's dental surfaces depends on the size of the particle. Fossil teeth from Hadar subjected to many cycles of weathering yielded mineral particles that are resistant to decay and dissolution (Figure 1b and 1c).

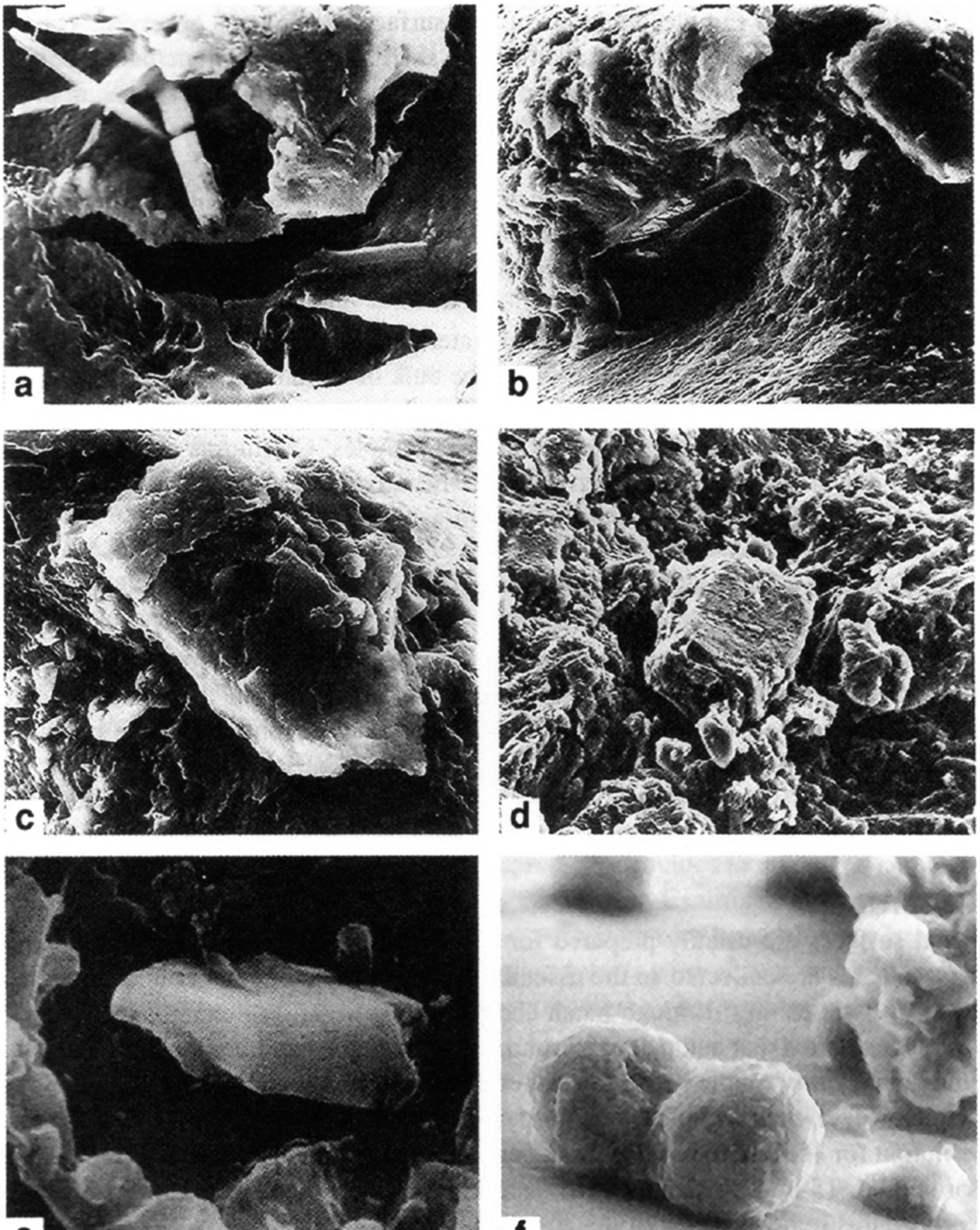
Soil has the capacity for absorbing certain materials from solution. The reaction involves both positively and negatively charged ions. The bulk of cations on the exchange complex generally consists of calcium, magnesium, sodium, potassium, aluminium and hydrogen. Therefore we may compare the cations of various samples. Calcium is ubiquitous as large deposits on dental surfaces. In La Ferrassie, the negatively charged sulfur ions (anions) is bonded with the calcium mineral particles (Figure 1d).

Tooth root canal is a place where micro-contents accumulate when the canal has been opened. The minerals extracted from the upper incisor root canals of Mozart's skull are of the same nature as the sand samples from the St. Marx cemetery where Mozart was inhumed (Figure 1e). Cells deposited by organic fluids are glued on the fractured anterior crowns. The broken edges being sharp, we surmise that the front teeth have been broken off by trauma received during transport prior to or during burial (Figure 1f). The traces of soft tissues on the tooth sockets suggest that burial period was short enough to preclude total surface decay.

DISCUSSION

Dental surfaces are usually prepared for micro-analysis. However, only the phytoliths resistant to acids are collected so the assemblage is incomplete. The organic component is removed by "wet-ashing" through harsh chemical treatments. For example, Lalueza et al. (1996) reconstructed diet and paleoenvironment through the examination of crushed pieces of removed calculus coupled with the search for phytoliths spatially related to the enamel surface. However, their samples were prepared by immersion of the tooth in a 20% acetic acid solution for 15 min. to remove carbonate deposits from the surface, then in 70% alcohol for another 15 min. to remove acid residues and finally in distilled water. These cleaning procedures removed most of the acquired deposits.

It has been assumed that tooth-to-tooth contact prevents the preservation of occlusal particles on surfaces, but our inspection of fossil and sub-actual teeth identified deposits mainly in the altered areas where exogenous deposits are easily trapped and impacted during tooth occlusion. The size of the particles bonded to the tooth surface provides a possible explanation for their presence. The minute size prevents the chewer from perceiving the product as objectionably "gritty" but, in spite of their small size, the particles are abrasive and easily press into enamel or dentine. Less abrasive material has a smaller adhesive



Figures 1. a : Gypsum surface deposits on *Dryopithecus* ISP 16 dentine surface 2.250x; b : *Australopithecus* AL 266 2nd right lower premolar root canal with deposits 563x; c : magnification of fragmented silica particles enlarged from figure n°2: 1.200x; d : *Homo sapiens* from neandertal man La Ferrassie 1. Square calcium embedded in sulfur near the root canal of the central upper right incisor; e : Quartz sand from an upper incisor root canal of Mozart's skull; f : Cells on the broken edge of one fractured upper incisor in Mozart's skull.

potential. When a hollowed-out place (e.g., a cavity or even a depression) is large, some particles settle to the bottom. A relatively soft mineral such as gypsum, which has a hardness of only 2 on the Mohs scale, is ground into smaller particles in comparison to a relatively hard mineral such as opaline silica (5.5-6.5 on the Mohs scale). Thus, silica, a major constituent of soil, is present in larger particle sizes. More importantly, slightly acid ground water dissolves the mineral calcite into smaller particle sizes. These chemical and mechanical explanations proposed for the particle size range of bonded particles excludes the simples inference of a direct relation of the particle size to a given diet.

CONCLUSION

Identification by micro-analysis is a complex procedure involving different areas of knowledge. Facts concerning the origin, persistence and frequency of surface deposits are to be established by comparison. Nitrocellulosic extractive replicas subject to electron microprobe analysis give information about the soil matrix as well as all aspects of surface deposits that may provide information about ancient teeth. Since the particles are *in situ* as the tooth replicas are examined, this method is a simple and reliable way of obtaining permanent records that can be used to reconstruct subsistence patterns and past environments, to reveal post-mortem degradation, to analyse substances of biological origin, and to identify dental activities (Puech 1980).

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